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SPECIFICATION

Closed-end Type Coil Spring with decreased Initial Deflection

5 TECHNICAL FIELD .

The present invention relates to a coil spring used in a buffer spring and like components of an automobile.

BACKGROUND ART

10 In order to improve an automobile and a bicycle in riding comfort in response to a road condition, a large number of inventions have been disclosed with respect to a coil spring for supporting a vehicle body. For example, in a coil spring described in both Japanese Utility Model application Laid-open No. Sho 56-20140 and Japanese Patent  
15 Publication No. Hei 2-22252, an elastic spacer is mounted in an intermediate portion of a coil element rod of the coil spring in order to change a coil constant in response to a road condition.

In a coil spring described in Japanese Utility Model application Laid-open No. Sho 57-113739, a coiled spacer provided with an  
20 appropriate number of convolutions is inserted into a proximal terminal portion of the coil spring, so that the number of effective or active convolutions of the coil spring is changed so as to change the coil spring in its coil constant.

Further, a coil spring described in Japanese Patent application  
25 Laid-open No. Hei 6-42563 relates to a wearing washer for preventing the coil spring from inclining due to its buckling when the coil spring is of an open-end type.

In contrast with these coil springs, the present invention improves a coil spring in spring properties by decreasing an amount

of initial deflection, wherein the initial deflection is a problem inherent in a coil spring of a closed-end type as described later.

Coil springs used in a buffer spring and like components of an automobile are classified into: a coil spring of closed-end type as shown in Fig. 3(a), wherein a terminal portion of the coil spring is subjected to a flattening process; and, a coil spring of open-end type as shown in Fig. 3(b), wherein a terminal portion of the coil spring is constructed of a part of an active convolution of the coil spring.

In the case of the coil spring of open-end type shown in Fig. 3(b), when a compression force is applied to the coil spring by using a flat washer, an oblique force which is obliquely directed with respect to a coil axis of the coil spring is developed to have the coil spring inclined under the influence of its buckling caused by such oblique force.

Consequently, this type of the coil spring is disadvantageous in that it is necessary for the coil spring to use a special washer such as one disclosed in the Japanese Patent application Laid-open No. Hei 6-42563. In contrast with this, in the case of the coil spring of closed-end type as shown in Fig. 3(a), even when a flat washer is used, it is possible for the flat washer to apply a force uniformly to the coil spring in axial direction thereof without using any special washer. Consequently, in this respect, the coil spring of such closed-end type is advantageous.

In the case where a compression force is applied to the coil spring: when the coil spring is of the open-end type, as shown in dotted line of Fig. 4(a), a plot of the coil spring of the open-end type forms a straight line from its starting point in a load-deflection diagram of Fig. 4(a). As for the spring constant

too, as shown in dotted line of Fig. 4(b), a plot of the coil spring of the open-end type forms a straight line from its starting point in a coil spring-deflection diagram of Fig. 4(b). In contrast with this, in the case of the coil spring of closed-end type, as shown  
5 in solid line of Fig. 4(a): a terminal portion of the coil element rod of the coil spring is initially deflected under a relatively light load since such terminal portion of the coil spring of the closed-end type is smaller in cross-sectional area than any one of active convolution portions of the same coil spring; and, after  
10 that, a plot of the coil spring of the closed-end type reaches its predetermined consistent form in the load-deflection diagram of Fig. 4(a). As for its spring constant, as shown in solid line of Fig. 4(b), a plot of the coil spring of the closed-end type gradually increases from its starting point, and reaches its consistent value  
15 at a completion point of its creeping. In this respect, the coil spring of the closed-end type is disadvantageous. In the present invention, such initial deflection occurring in the coil spring of the closed-end type under the relatively light load is hereinafter referred to as "initial deflection".

20 In order to avoid the above-mentioned disadvantage inherent in the coil spring of the closed-end type, it is considered that a preliminary load is applied to the coil spring in installation to preliminarily remove the initial deflection of the coil spring from the coil spring's installation height. However, in this method,  
25 since the coil spring is substantially decreased in coil height in installation, it is not possible to carry out this method in some application cases. Due to this, a need exists in the art for the coil spring of the closed-end type, which spring is substantially released from a problem of the initial deflection by using a flat

washer.

#### SUMMARY OF THE INVENTION

Consequently, it is an object of the present invention to solve  
5 the above problem by providing a coil spring of closed-end type,  
wherein: the coil spring of the closed-end type is decreased in  
initial deflection as is in the case of a coil spring of open-end  
type.

In order to accomplish the above object, the coil spring of  
10 the closed-end type decreased in initial deflection according to  
the present invention is characterized in that a coupler is fixedly  
mounted between: an outer peripheral surface of a terminal portion  
of a coil element rod of the coil spring; and, an outer peripheral  
surface of a convolution of the coil spring, which convolution is  
15 subsequent to the terminal portion of the coil element rod.

In other words, in the coil spring of the closed-end type of  
the present invention: in order to prevent occurrence of the initial  
deflection which is caused by the fact that the terminal portion  
of the coil spring of the closed-end type is smaller in  
20 cross-sectional area than a normal convolution portion of the coil  
spring and is therefore initially deflected under a relatively light  
load smaller than a given load, a force applied to the terminal  
portion of the coil spring is transmitted to the subsequent  
convolution of the coil spring by using the coupler, so that the  
25 amount of such initial deflection of the coil spring is decreased.

As a result of this, a load-deflection plot and a plot of spring  
constant of the coil spring of the closed-end type of the present  
invention each of which plots assumes a shape shown in Fig. 5. In  
other words, in the coil spring of the present invention, although

a slight amount of the initial deflection initially appears as shown in the drawings, such a slight amount of the initial deflection of the coil spring of the present invention is much smaller than the corresponding initial deflection of the conventional coil spring of the closed-end type (see Fig.4). Consequently, it is possible for the coil spring of the present invention to considerably decrease the amount of the initial deflection thereof. This makes it possible for the coil spring of the present invention to obtain substantially the same spring characteristics as that of the coil spring of open-end type. Further, it is possible for the coil spring of the present invention to use a flat washer as a wearing member for the coil spring. As a result, it is possible for the coil spring of the present invention to reduce its manufacturing cost.

In contrast with the coil spring of the known invention described in the Japanese Utility Model application Laid-open No. Sho 57-113739 in which the spacer is inserted into or removed from the coil spring so as to change the number of effective or active convolutions of the coil spring, the present invention has the coupler of its coil spring fixedly mounted on the coil spring at the beginning of its installation in order to keep a spring constant of the coil spring at a consistent value from the beginning of application of a compression force to the coil spring.

The coupler is preferably made of an elastic material. Further, preferably this coupler is made of an elastic material, which is moderate in both hardness and elasticity so as not to damage a coil element rod of the coil spring. Plastics, aluminum alloys, copper alloys and like materials can be used as the material of the coupler. As for a method for fixedly mounting the coupler on the coil spring, it is possible to bond the coupler to the coil spring with the use

of an adhesive. Further, it is also possible to fixedly hold the coupler in the coil spring with the use of resiliency of the coil spring.

5 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of the coil spring decreased in its initial deflection according to an embodiment of the present invention; Fig. 2 is a perspective view illustrating an example of the coupler of the present invention; Fig. 3 is a view describing both the coil spring of the closed-end type and that of the open-end type; Fig. 4 is a view illustrating the initial deflection of the coil spring of the conventional closed-end type; Fig. 5 is a view showing a load-deflection/spring constant diagram of the coil spring of the present invention when the spring is compressed; and, Fig. 6 is a view showing the compression test values of the embodiment of the present invention.

DESCRIPTION OF THE REFERENCE NUMERALS

1 a coil spring of closed-end type; 2 a coil  
20 element rod; and, 3 a coupler.

PREFERRED EMBODIMENT FOR CARRYING OUT THE INVENTION

An embodiment of the present invention, which embodiment is illustrated in the drawings, will be hereinbelow described in a concrete manner. Fig. 1 is a perspective view of a coil spring of closed-end type according to an embodiment of the present invention. Fig. 2 is a perspective view describing an example of a coupler of the present invention.

In Fig. 1, a coil spring of closed-end type of the present

invention is constructed of: a coil element rod 2 having each of its opposite coil terminal portions subjected to a surface-flattening process; and, a coupler 3 fixedly mounted on each of the opposite terminal portions 2a of the coil element rod 2, which terminal portions 2a are disposed in the vicinities of opposite ends of the coil element rod 2 (in Fig. 1: only one of the opposite ends of the coil element rod 2 is illustrated; and, the other is not omitted in the drawing.).

As shown in detail in Fig. 2, an example of the coupler 3 of the present invention is constructed of a block which is provided with: a groove 3a having a bottom radius, which radius permits the terminal portion 2a of the coil element rod 2 to be steadily inserted into the groove 3a; and, a groove 3b provided in a rear surface oppositely disposed from the groove 3a in the block, wherein the groove 3b of the block has a bottom radius permitting the block to steadily mount on an outer peripheral surface of a convolution of the coil element rod in a raiding manner, which convolution is disposed axially subsequent to the terminal portion (or convolution) 2a of the coil element rod 2. This makes it possible for the block to keep consistent a clearance between the terminal portion (or convolution) 2a of the coil element rod 2 and the corresponding outer peripheral surface of the axially subsequent convolution of the coil element rod 2 when the coil spring of the present invention is compressed. Preferably, this block is made of a suitable elastic material having a moderate hardness so as not to damage the coil element rod. Due to this, the block may be made of plastics and soft metals both low in hardness. As for a method for fixedly mounting the coupler on the coil spring of closed-end type of the present invention: although it is preferable to have at least one of the

grooves 3a, 3b of the coupler 3 is bonded to the coil element rod with the use of an adhesive, it is also possible to fixedly mount the block by a resiliency of the coil spring itself without using any adhesive.

5        Although the coupler 3 assumes a saddle-backed shape in the embodiment of the present invention so as to permit the coupler 3 to ride on the coil element rod 2 of the coil spring, it is also possible for the coupler 3 to have a through-hole permitting the coil element rod 2 of the coil spring to pass through such through-hole  
10 of the coupler 3, and also possible for the coupler 3 to assume any other suitable shape in place of the groove 3b of the block.

Now, the coil spring of the present invention having the above construction will be described in operation. When the coil spring is subjected to a compression force: in case of a coil spring of  
15 a conventional closed-end type not provided with any coupler, since a terminal portion 2a of such conventional closed-end type of coil spring is smaller in cross-sectional area than any other convolution portion of the same coil spring, so that the terminal portion 2a of such conventional closed-end type of coil spring is initially  
20 deflected and brought into contact with an outer peripheral surface of the subsequent convolution of the coil spring to make it possible for the coil spring to reach its consistent spring constant. Due to this, as shown in Fig. 4 described above, the initial deflection is developed in the conventional closed-end type of coil spring.

25        In contrast with this, in case of the coil spring of the present invention: when the coil spring is subjected to a compression force, the compression force applied to the terminal portion 2a of the coil element rod is transmitted to the subsequent convolution through the coupler 3, so that, as shown in Fig. 5, the terminal portion



2a of the coil element rod is substantially not deflected, which makes it possible for the coil spring of the present invention employing the coupler 3 to keep consistent its spring constant from substantially the beginning of its compression process. As shown in Fig. 5, since the initial deflection can be practically neglected in the coil spring of the present invention, it is possible for the coil spring of such closed-end type of the present invention to obtain substantially the same spring characteristics as that of the coil spring of open-end type.

As an example, a coil spring of closed-end type having mechanical properties shown in Fig. 1 were subjected to a series of compression tests in two modes one of which corresponding to the coil spring of the present invention; and, the other corresponds to the conventional coil spring which is not provided with any coupler.

The coupler was made of material called "Derlin".

TABLE 1: Mechanical Properties of the Coil Spring thus tested

Steel Grade	SAE 9254
Tensile Strength (N/mm <sup>2</sup> )	1.991
Spring Constant (Kg f/mm)	8.0
Coil Element Rod Diameter (mm)	11.80
Coil's Outer Diameter (mm)	88.6
Total Number of Convolutions	6.85
Free Height (mm)	203.0

The results of the compression tests are shown in Fig. 6. As is clear from the drawing, in the conventional coil spring which is not provided with any coupler: the initial deflection thereof was measured until the coil height of the coil spring reached a value of 185 mm. In contrast with this, in the coil spring of the present invention: when the coil spring having a free height was

compressed by an amount of 3 mm and reached a coil height of 200 mm, the coil spring showed its consistent spring constant. In other words, the coil spring, which is practically and substantially free from the initial deflection, was obtained.

5       As described above, in the coil spring of closed-end type of the present invention decreased in its initial deflection, the elastic coupler fixedly mounted between: the outer peripheral surface of the terminal convolution of the coil element rod; and, the outer peripheral surface of the subsequent convolution of the same coil element rod, may transmit the compression force applied to the terminal convolution of the coil element rod to the subsequent convolution of the same coil element rod. Consequently, it is possible for the coil spring of the present invention to prevent the initial deflection from being developed during its compression process.

10       The initial deflection is a problem inherent in the closed-end type of the conventional coil spring, because: the conventional coil spring of closed-end type has its coil terminal portion more decreased in cross-sectional area than any other portion of the coil spring in construction; and, is therefore deflected first even when

15       subjected to a smaller force than a given load of the coil spring.

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      Due to this, it is possible for the coil spring of the present invention, which uses the flat washers but not uses any special washer, to realize substantially the same spring characteristics as that of the coil spring of open-end type provided with the special

25       washers.

      Disclosed in the Japanese Utility Model application Laid-open No. Sho 57-113739 is a conventional coil spring of a known invention. This type of conventional coil spring uses a spacer which is detachably inserted between selected adjacent ones of active

convolutions of the coil spring in order to change the number of its effective or active convolutions to change a spring constant of the coil spring. In contrast with this, it is an object of the coil spring of the present invention to keep substantially consistent its spring constant from the beginning of application of a given load to the coil spring by fixedly mounting the coupler on the terminal portion of the coil element rod in the vicinities of the opposite end of the coil spring.

As for the coupler, preferably the coupler is provided with a moderate hardness and elasticity so as to prevent the coil element rod of the coil spring from being damaged by the coupler. As for a method for fixedly mounting the coupler on the coil spring, it is possible to employ any suitable method, for example such as: a bonding method in which the coupler is bonded to the terminal portion or convolution of the coil spring through a suitable adhesive applied to the terminal portion of the coil spring; and, a mechanical method in which the coupler is fixedly mounted on the terminal portion or convolution of the coil spring under the influence of a resilient force exerted by the coil spring.

#### POSSIBILITY IN INDUSTRIAL USE

As described above, in the coil spring of closed-end type of the present invention is decreased in initial deflection: in contrast with the coil spring of open-end type using the special washers, any special washer is not required in the coil spring of the present invention; and, in place of such special washer, a flat washer is used in the coil spring of the present invention. Due to this, it is possible for the coil spring of the present invention to realize substantially the same spring characteristics as that of the coil

spring of open-end type. As a result, it is possible for the present invention to increase the application field of the coil spring of closed-end type according to the present invention.